Putting the pieces of the puzzle together: age and sex-specific estimates of migration amongst countries in the EU/EFTA, 2002–2007

Raymer, James; Beer, Joop; Erf, Rob

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James Raymer

Southampton Statistical Sciences Research Institute, University of Southampton

Joop de Beer

Netherlands Interdisciplinary Demographic Institute

Rob van der Erf

Netherlands Interdisciplinary Demographic Institute

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Putting the Pieces of the Puzzle Together: Age and sex-specific estimates of migration between EU / EFTA countries, 2002-2007

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Abstract

Because of inconsistencies in reported flows and large amounts of missing data, our knowledge of international migration patterns in Europe is limited. Methods for overcoming data obstacles and harmonising international migration data, however, are improving. In this paper, we provide a methodology for integrating various pieces of incomplete information together, including a partial set of harmonised migration flows, to estimate a complete set of migration flows by origin, destination, age and sex for the 31 countries in the European Union and European Free Trade Association from 2002 to 2007. The results represent a synthetic data base that can be used to inform population projections, policy decisions and migration theory.

Key words

international migration, Europe, log-linear models, combining data

Assembler les pièces du puzzle: estimations de la migration entre les pays de l'UE et de l'AELE par âge et par sexe, 2002-2007

Résumé

Du fait d'incohérences dans l'enregistrement des flux migratoires et du grand nombre de données manquantes, notre connaissance des schémas de migrations internationales en Europe reste limitée. Cependant, les méthodes disponibles pour surmonter les obstacles liés aux données et pour harmoniser les données sur la migration internationale s'améliorent. Dans cet article, nous proposons une méthode pour combiner les différents éléments de ces informations incomplètes, incluant un ensemble partiel de données harmonisées sur les flux migratoires, afin d'estimer une série complète de flux migratoires par pays d'origine, pays de destination, âge et sexe pour les 31 pays de l'Union Européenne et de l'Association Européenne de Libre Echange de 2002 à 2007. Les résultats constituent une base de données synthétique pouvant servir de base pour les projections de population, les décisions politiques et les théories relatives à la migration.

Mots clés : migration internationale, Europe, modèles log-linéaire, données combinées

Putting the pieces of the puzzle together: Age and sex-specific estimates of migration between EU / EFTA countries, 2002-2008

1. Introduction

The development of European Community policies and legislation on migration and asylum has highlighted the need for comprehensive and comparable European statistics on a range of migration-related issues. The Thessaloniki European Council of 20 June 2003 concluded that more effective mechanisms are needed for the collection and analysis of information on migration and asylum in the European Union (EU). In 2007, the European Parliament passed a regulation to govern the supply of national statistics to the EU. Countries are now required to provide harmonised migration flow statistics to Eurostat in accordance to Regulation 862/2007[1]. The regulation obliges Member States to make the best use of available data and to produce statistics that are comparable across Europe, requiring a harmonised definition of migration and migrants. However, Member States are not required to introduce completely new data sources or to change existing administrative systems for immigration and asylum. In accordance with the principle of proportionality, the regulation confines itself to the minimum required to achieve the objective of harmonised Community statistics on migration and asylum. To help overcome obstacles regarding migration data, Article 9 of the Regulation states that 'As part of the statistics process, scientifically based and well documented statistical estimation methods may be used.' (p. 7).

In this paper, we present a methodology to combine various pieces of information on migration to produce a consistent and complete set of age- and sex-specific migration flow estimates between the 31 countries in the EU[2] and European Free Trade Association (EFTA)[3] from

[1]http://europa.eu/legislation_summaries/justice_freedom_security/free_movement_of_persons_asylum_immigration/l14508_en.htm
[2] The 27 countries in the EU are Austria (AT), Belgium (BE), Bulgaria (BG), Cyprus (CY), Czech Republic (CZ), Denmark (DK), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (GR), Hungary (HU),

2002 to 2007. The pieces of information available to us include a harmonised data set of migration flows between 19 EU / EFTA countries (de Beer et al. 2010), covariate information, and two incomplete data sets on immigration by age and sex and emigration by age and sex, obtained from Eurostat, the statistical branch of the European Union. Using the harmonised migration flow matrix as a base, we first estimate the missing origin-destination-specific data to produce a complete matrix of flows between all 31 countries in the EU / EFTA. These flows are then disaggregated by age and sex for the years 2002-2007 by using a log-linear modelling framework and iterative proportional fitting. The methodology developed in this paper not only helps Member States fulfil the 2007 Regulation, but also provides estimates for assessing reported figures (by various countries) and for providing a more complete understanding of the migration patterns within Europe.

2. Available Data

The United Nations (1998) recommends that long-term international migrants be defined as persons who move to a country other than their usual residence for a period of at least one year. In reality, countries tend to gather migration data according to their own needs (often for legal purposes) or to be consistent with historical collection methods. Furthermore, until very recently, there have been no real incentives for countries to adjust their data collection methods to provide internationally comparable migration statistics. This means that, in order to understand or predict how international migration between countries evolves over time, one must have a good sense of the various migration data typologies and the determinants of migration. There have been many analyses of the issues and problems associated with international migration flow data (see, e.g., Kelly 1987; Kraly and Gnanasekaran 1987; Champion 1994; Willekens 1994, 2008; Bilsborrow et al. 1998; United Nations 2002; Nowok et al. 2006; Poulain et al. 2006; Kupiszewska and Nowok 2008;

Irish Republic (IE), Italy (IT), Latvia (LV), Lithuania (LT), Luxembourg (LU), Malta (MT), Netherlands (NL), Poland (PL), Portugal (PT), Romania (RO), Slovakia (SK), Slovenia (SI), Spain (ES), Sweden (SE) and United Kingdom (UK).

[3] The four countries in the EFTA are Iceland (IS), Liechtenstein (LI), Norway (NO) and Switzerland (CH).

Thierry 2008; Abel 2010). In this section, we summarise the main issues concerning the reported flows in Europe.

The availability of statistics on international migration flows is conditioned by the existence of a data collection system that has the potential of yielding meaningful statistical information on changes in place of usual residence. The major types of data sources used to produce statistics on international migration flows can be summarized as follows:

1) population registration systems, including centralised population registers and local population registers);
2) other administrative registers related to foreigners, alien's registers, residence permit databases or asylum seekers databases;
3) statistical forms filled in for all changes of residence; and
4) border crossing data collection and others sample surveys.

Some information on international migration flows can also be derived from population censuses, but this source has a number of well-known limitations. The main ones are that they are (i) carried out at longer intervals, e.g., every five to ten years, (ii) not able to capture all of the migration events that occur between enumerations, and (iii) capable of only identifying immigrants, as emigrants are no longer present to be counted. Because of these reasons, migration flow data obtained from censuses are usually not considered for the reporting of international migration flows.

The availability of statistics is not an end in itself. Even if data are available, their poor quality may render them useless. There are two main factors that make international migration statistics unreliable. The first is the under-registration of migrations, which applies in particular to countries where data-collection systems rely on self-declarations of international movements. The second relates to data coverage: the data collection system used in a country may not cover the whole target population and so some subsets are excluded from the statistics (e.g., asylum seekers or students). In addition to the above two factors, data might be unreliable if a lot of errors arise during data processing.

As a vast majority of international migration statistics in the EU / EFTA countries are derived from population registers,[4] deficiencies in registration have the greatest influence on data reliability. The willingness to report changes in place of residence vary from one country to another, but everywhere, people take into account the advantages and disadvantages resulting from being registered or not. In general, they have more interest in reporting their arrival than their departure. Therefore, within a given country, immigration statistics are usually considered more reliable than emigration statistics. Origin-destination-specific migration data based on sample surveys are not considered reliable (except for very large flows) due to estimation errors and generally high volatility over time.

Regarding coverage, flows of undocumented migrants are generally not included (for obvious reasons). Furthermore, asylum seekers are often only included when they have been granted a refugee status and received a temporary or permanent residence permits. Students are another group of people who are in a grey area of the registration of international migrations. Not all EU students are included in the population registers of the receiving country or deregistered after they have left. For students originating from outside the EU / EFTA, the situation is considered more reliable, as all of them are required to obtain a specific residence permit.

Despite existing recommendations from the United Nations and the EU, the definitions of international migrants vary significantly between countries, within countries over time, and between different sources of statistical information. Moreover, the definitions of immigration and emigration that are applied in a particular country do not necessarily match in terms of the time criterion. Most countries base their definitions of international migration on a change of country of residence. A

[4] The United Kingdom and Cyprus use a passenger survey to obtain information on migration flows. Ireland uses a Labour Force Survey.

variety of possible interpretations of this term results in a lack of clarity in the statistics. It can be interpreted from a legal (de jure) or an actual (de facto) point of view. In the former, the laws and legislations binding in a country in question specify requirements that have to be fulfilled in order to become a resident. The conditions differ between nationals and non-nationals, and between non-nationals there are two distinct groups, namely foreigners with the right to free movement and others. In fact, nationals have an unconditional right of residence in their country of citizenship, whereas the rights of foreigners are hedged in with conditions. Nationals may still be counted as part of the population of their country of citizenship even after they have been living abroad for a number of years. Thus, having a place of residence in a country does not necessarily mean a physical presence on its territory. From the de facto perspective, residence is directly connected with presence in the country in question. Usually, presence must be for a specified minimum period of time.

Therefore, time should be considered as a supplementary concept to that of residence. However, the level of concreteness differs across countries. On the one hand, the definitions currently in use often specify that international migration takes place when there is a change in the country of residence for a minimum period of time. Such a period is precisely defined. On the other hand, some countries take only "permanent" changes of residence into account without specifying a precise duration.

When a precise period is used, another problem arises related to the distinction between intended and actual duration. The use of the actual duration concept means that the production of the statistics would be systematically delayed by the period used as the time criterion in the definition of migration. Currently, all countries which specify a precise period use the intended duration. As a consequence, the assumption is made that the intended duration will become the actual one. In reality, the two measures may differ considerably, depending on the country and situation.

As well as discrepancies in the definitions of crucial concepts described above, there are a number of other problems that considerably hinder the international comparability of flow data. First, migration events are counted at various dates. For immigration this might be the date of issuing a permit, the date of arrival or the date of reporting for registration. For emigration, the date of expiry of a permit, the date of reporting the departure or the date of departure are variously used. Secondly, in some cases a reference period other than a calendar year might be applied (e.g., April to April in Ireland). In addition, when a very short (or no) duration of stay criterion is employed, an individual may migrate several times during the reference period. All of these events are counted separately in the international migration statistics. When the one year time limit is strictly applied and the data are collected on a yearly base, only one migration (immigration or emigration) can be counted for a given migrant and, accordingly, there should be no difference between the number of migrants and the number of migrations.

This brief review leads to the general conclusion that currently available data on international migration flows are still far from being internationally comparable. This is evident when comparing data on flows between pairs of countries that are reported by countries of origin and countries of destination, using a so-called double-entry matrix. In an ideal world the emigration figures produced by sending countries and the immigration figures collected by receiving countries would be similar if the two data-collection systems use identical definitions and the data are reliable and complete. However, the real world demonstrates the weak comparability of the available data.

To provide an illustration of what the reported data actually look like, consider the subset of migration flows between ten countries in the EU for 2003 presented in Table 1. For each migration flow, there are two possible values: one reported by the receiving country (R) and one reported by the sending country (S). However, for the 2003 data, there are four data situations present: flows reported by both the receiving and sending country (e.g., Czech Republic to Germany or Spain to Italy), flows only reported by the receiving country (e.g., from France to Germany), flows only reported by the sending country (e.g., from Germany to Greece) or no flows reported (e.g., Belgium to France or France to Belgium). Furthermore, where flows are available from both the sending and receiving countries, the numbers rarely match. For example, one might take the average of the two reported flows from Germany to Spain (i.e., 13,746 and 16,236) as a reasonable estimate, as the numbers are relatively close to each other. However to take the average of the two reported flows from Spain to Germany (i.e., 14,647 and 2,109) would most likely result in a very poor estimate. In this situation, one might consider one flow to be more accurate than the other. Deciding which flow is more accurate than the other has consequences for the other situations where only one reported flow is available, e.g., from Spain to Belgium or from France to Spain.

-------- Table 1 about here --------

For the estimation of migration patterns in this paper, we take advantage of the recent work by de Beer et al. (2010), who developed a methodology to harmonise migration flows benchmarked to the United Nations definition of duration for movements between 19 EU / EFTA countries from 2002 to 2007 (i.e., all the countries providing both country-specific immigration and emigration flows). The methodology accounted for differences in definitions and the effects of measurement error due to, for example, under reporting and sampling fluctuations. The differences between the two sets of reported data were overcome by estimating a set of adjustment factors for each country's immigration and emigration data, taking into account any special cases where the origin-destination patterns did not match the overall patterns. More specifically, optimisation was used to minimise the differences between the two sets of reported data pooled over time. The estimated adjustment factors were then used to obtain harmonised estimates of migration flows for 19 countries providing both immigration and emigration flows by country of previous residence and next residence, respectively.

3. Methodology

3.1 Background

A migration flow table can be considered a two-way (origin by destination) contingency table, where the cells represent counts of migrants (or persons making moves). In the early 1980s, Willekens (1982, 1983) proposed a log-linear approach to model the main effect and interaction structures contained in migration flow tables. In this approach, auxiliary information may be included via offsets, including structural zeros to remove cells representing non-migrants or intra-national migrants from the estimation process. For example, a log-linear-with-offset model is specified as

$$\ln(\hat{n}_{ij}) = \lambda + \lambda_i^O + \lambda_j^D + \ln(n_{ij}^*), \qquad (1)$$

where n_{ij}^{*} represents the offset or auxiliary information, λ is the overall effect, λ_i^{O} is the origin main effect and λ_j^{D} is the destination main effect. This model provides estimates of migration that are consistent with the observed (or estimated) margins of the migration flow table (i.e., n_{i+} and n_{+j}) but borrow the associations between origins and destinations from the offset, n_{ij}^{*} (Rogers et al. 2003).

During the past ten years, there have been several papers focusing on describing and modelling the structures of *internal migration* found in tables cross-classified by origin, destination and age or some other categorical variable (Rogers et al. 2002, 2003; Sweeney and Konty 2002; Raymer et al. 2006; Raymer and Rogers 2007; van Wissen et al. 2008). The description and estimation centres on these structures rather than on the flows themselves. For instance, the multiplicative component model for describing the structures of an origin (*O*) by destination (*D*) table of migration flows is specified as

$$n_{ij} = (T)(O_i)(D_j)(OD_{ij}),\ i \neq j \qquad (2)$$

where n_{ij} is a migration flow from origin *i* to destination *j*. There are four multiplicative components in total: an overall level, two main effects and one two-way interaction or association component. This decomposition, for example, can be used to assess whether an increase in a particular flow occurred because of an increase in overall attractiveness of the region (i.e., marginal effect), because of an increase in the connectedness between two places (i.e., interaction effect), or as a consequence of both.

The multiplicative components in Equation 2 are calculated with reference to the total level in the migration flow tables. The *T* component represents the total number of all migrants in the system. The main effect components, O_i and D_j, represent proportions of all migration from each origin and to each destination. The two-way interaction component represents the ratio of observed migration to expected migration (for the case of no interaction) and is calculated as $OD_{ij} = n_{ij}$ / $[(T)(O_i)(D_j)]$. The OD_{ij} component captures the association or "connectivity" between origins and destinations.

The multiplicative component model is useful framework for estimating migration flows because it makes a distinction between an overall level, main effects, and interaction effects in contingency tables with parameters that can be used to guide the estimation process. This means that one can focus on modelling the underlying structures of migration flows via the multiplicative components. Also, the estimation process can be carried out in a systematic manner working from marginal effects to interaction effects. As described below, this model can also be extended to include other categorical variables, such as age groups and sex. In fact, this modelling framework has been used in a variety of settings, for example, to project future age-specific migration patterns in Italy (Raymer et al. 2006), to combine migration data from multiple sources to study economic activity flows in England (Smith et al. 2010) and to construct missing origin-destination associations for migration between countries in Europe (Raymer 2007, 2008).

Finally, the log-linear-with-offset model (Equation 1) produces the same estimates as those obtained from iterative proportional fitting (Deming and Stephan 1940; Fienberg 1970; Haining et al. 1984; Wong 1992; Johnston and Pattie 1993), which is a relatively simple (mathematical) technique that has been used for "updating" incomplete migration flow tables (Willekens 1982, 1983; Nair 1985; Rees and Duke-Williams 1997). As with the log-linear-with-offset model, this method may be used, for example, to revise a historical (or auxiliary) table of migration flows by forcing it to fit, bi-proportionally through iteration, a more recent set of marginal totals with missing cell counts, where the marginal totals may represent beginning and ending populations or total immigration and emigration by country.

3.2 *Completing the Origin-Destination Matrix*

Our starting point for estimating the complete and consistent set of migration flows between 31 EU / EFTA countries from 2002 to 2007 is a harmonised data set of migration flows between 19 EU / EFTA countries provided by de Beer et al. (2010). Our estimation procedure that we have developed is a hierarchical one based on the multiplicative component model (Equation 2). First, the 12 missing immigration and emigration totals[5] of the complete migration flow table are estimated, followed by the corresponding origin-destination interaction terms (OD_{ij}).[6] In the next subsection, we describe how these flows can then be disaggregated by age and sex.[7]

For the migration totals, four similar ordinary least squares (OLS) regression models are used to estimate the natural logarithms of

1) immigration to the 31 EU / EFTA countries from the 31 EU / EFTA countries,
2) immigration to the 31 EU / EFTA countries from the rest of the world,
3) emigration from the 31 EU / EFTA countries to the 31 EU / EFTA countries, and
4) emigration from the 31 EU / EFTA countries to the rest of the world.

The main predictor variables are:

1) population size (in thousands, natural logarithm),
2) percentage of the population aged 65 and over,
3) life expectancy of females,
4) relative GDP,
5) percentage urban, and

[5] The 12 countries with missing data are Belgium, Bulgaria, Estonia, France, Greece, Hungary, Ireland, Lichtenstein, Malta, Portugal, Romania and Switzerland.
[6] In both cases, we used SPSS's linear regression procedure.
[7] Here, we used SPSS's log-linear procedure.

6) indicator variables for the calendar years and Germany.

The selection of these variables, and the ones below for origin-destination associations, are based on migration theory, data availability and recent work by Jennissen (2004), Raymer (2008) and Abel (2010). In general, we expect large populations to both send and receive large numbers of migrants relative to countries with smaller populations; younger societies will send relatively more migrants than older societies; populations with higher levels of wellbeing (where life expectancy is a proxy) and GDP will attract relatively more migrants; and countries with higher proportions of urban populations to be more mobile than those with lower proportions. The indicator variable for Germany was used to control for its relatively large size, i.e., to prevent this country from dominating the patterns of smaller countries. With the exception of percentage urban, these variables were all available for the years 2002-2007. The regressions were carried out on the total harmonised migration flows estimated by de Beer et al. (2010).

The estimated regression coefficients for the four models described above are set out in Table 2. The adjusted R^2 values were above 0.90 for all models except for the one predicting emigration to the rest of the world (R^2 = 0.75). The coefficients for population (positive) and percent 65 years and older (negative) were significant at the 0.05 level for all four models. The coefficients for female life expectancy (a proxy for wellbeing) were significant for three of the four models with the signs positive for immigration and negative for emigration to EU / EFTA countries. This means that countries with high life expectancies are relatively attractive to migrants from elsewhere and are also able to retain relatively more migrants as a result. The same story can be said, more or less, for GDP per capita (a proxy for earnings), also significant for three of the four models. Interestingly, the percent urban, the 2005-2007 indicator variables (increasing in a linear fashion) and the Germany indicator variables were significant only for the immigration and emigration models representing flows within the EU / EFTA. Here there is clear evidence that differences exist between migration within the EU / EFTA system and outside it. The above results are largely in agreement with macro-level migration theories. The only results that might appear strange are the negative coefficients for percent 65 years and older in the two immigration models. The idea that older societies attract fewer migrants makes sense if one remembers that life expectancy and GDP per capita are controlled for, and that these societies may be relatively less mobile overall due to their older populations.

The coefficients from the four regression models were used to obtain estimates of total immigration and emigration for the 12 countries with missing data. The EU / EFTA totals, however, had to be adjusted so that the sums of immigration and emigration matched. This was done by simply dividing the difference by two and proportionally subtracting that amount from the predicted immigration totals and proportionally adding it to the predicted emigration totals.

----- Table 2 about here -----

The next step in our model framework is to estimate the missing origin-destination associations (i.e., OD_{ij} in Equation 2). Similar to the estimation of missing marginal totals, we used ordinary least squares regression, pooled over time, to estimate the natural logarithm of association terms for migration between the 12 missing EU / EFTA countries. The predictor variables are

1) contiguity (i.e., whether a country was a neighbour or not),
2) indicator variables for migration between the new accession countries and Ireland and the United Kingdom,
3) language family (i.e., 1 = same language family, 0 = different language family),
4) natural logarithm of gross national income in purchasing power parity (GNI PPP) per capita ratios,[8]
5) natural logarithm of distance (between capital cities),

[8] Obtained from the Population Reference Bureau's World Population Data Sheets (http://www.prb.org/).

6) natural logarithm of foreign-born population stock associations between country *i* and *j*,[9] and

7) natural logarithm of trade flow associations between country *i* and *j*.[10]

These variables capture the associations between regions by focusing on the social and physical 'distance' factors, as well as the economic factors representing relative wages and flows of trade. The association terms for foreign-born population stocks and trade flows are calculated in the same way as the OD_{ij} terms are in Equation (2). That is, the observed stocks or flows from *i* to *j* are divided by the overall level (n_{++}) multiplied by the proportion from origin *i* (n_{i+} / n_{++}) and the proportion to *j* (n_{+j} / n_{++}), thus allowing us to control for the different "sending" and "receiving" levels in the foreign-born population stock and trade flow tables. These measures also correspond closely to what we are predicting, i.e., the association terms of migration from *i* to *j*. The regression resulted in an R^2 of 0.41 with all predictor variables being significant except language family and distance. The coefficients from this regression, set out in Table 3, were then used to estimate the origin-destination interactions between the 12 countries with missing data.

----- Table 3 about here -----

The predicted origin-destination association terms (i.e., OD_{ij}) are shown in the lower right hand corner of Table 4, along with the corresponding terms of the 2007 harmonised data. They range from 0.10 for the Romania to Liechtenstein flow to 5.85 for the Bulgaria to Romania flow. In other words, the migration flow from Romania to Liechtenstein is predicted to be much smaller than expected, whereas the flow from Bulgaria to Romania (i.e., two neighbouring countries) is predicted to be nearly six times larger than expected. Finally, multiplying the expected migration flows by these estimated interactions yielded the estimates of the flows between the 12 countries with missing data. The results are described below in Section 4.1.

[9] Obtained from the Global Migrant Origin Database (http://www.migrationdrc.org/research/typesofmigration/global_migrant_origin_database.html).
[10] Obtained from the United Nations Commodity Trade Statistics Database (http://comtrade.un.org/).

----- Table 4 about here -----

3.3 Disaggregating by Age and Sex

The complete set of origin-destination flows, estimated using the methodology described in the previous section, may be disaggregated by age and sex by using a multiplicative component model approach. Because the tables now have four dimensions, we denote cross-classified tables by letters. For example, OD is a two-way (origin by destination) table of migration flows, OAS is a three-way (origin by age by sex) table of migration flows and ODAS is a four-way (origin by destination by age by sex) table of migration flows. The (saturated) multiplicative component model for an ODAS table of migration flows is specified as

$$\begin{aligned} n_{ijxy} = {} & (T)(O_i)(D_j)(A_x)(S_y) \\ & (OD_{ij})(OA_{ix})(OS_{iy})(DA_{jx})(DS_{jy})(AS_{xy}) \\ & (ODA_{ijx})(OAS_{ixy})(ODS_{ijy})(DAS_{jxy}) \\ & (ODAS_{ijxy}) \end{aligned} \tag{3}$$

where n_{ijxy} is an observed flow of migration from origin i to destination j for age group x (i.e., 0-4, 5-9, ..., 85+ years) and sex y. There are sixteen multiplicative components in total: an overall level (T), four main effects, six two-way interaction components, four three-way interaction components and a single four-way interaction component. For this study, however, we do not have complete information. Instead we only have three separate tables:

1) a complete OD table (estimated) for the years 2002-2007,

2) an incomplete OAS table provided by Eurostat for the years 2002-2006, and

3) an incomplete DAS table provided by Eurostat for the years 2002-2006.

For the disaggregation by age and sex, one first needs to identify an overall model that can accurately predict the migration flows. We did this by comparing various unsaturated log-linear model fits of the two available three-way migration flow tables, i.e., OAS and DAS, for the 2002-2006 periods. Using the likelihood ratio statistic as a goodness-of-fit measure and visual comparisons of the predicted flows with the reported flows, we found that the two-way interaction models, OA, OS, AS and DA, DS, AS, did very well in predicting the OAS and DAS tables, respectively. For the OAS flows, the likelihood ratio statistic for the two-way interaction model was 38,927 with 357 residual degrees of freedom (rdf), which was considerably lower than any of the other unsaturated models. For instance, the likelihood ratio statistics for the simpler OA, AS and OA, OS models were 103,819 (rdf = 378) and 143,639 (rdf = 374), respectively. The same story was true for the DAS flows. Here, the likelihood ratio statistic for the two-way interaction model was 83,007 with rdf = 391, while the statistics for the competing DA, DS and DA, AS models were 171,780 (rdf = 408) and 147,288 (rdf = 414), respectively. Furthermore, an inspection of the age-specific patterns of the predicted flows based on the two-way interaction models (not shown for space reasons) showed that they were practically indistinguishable from the corresponding reported flows.

Because ODA tables are not available for migration between countries in the European Union, we were not able to test whether the three-way interaction between origin, destination and age was significant. However, based on recent analyses of age-specific internal migration, we can assume these terms, for the most part, would not contribute much to the estimation of the flows. Raymer and Rogers (2007) and Raymer et al. (2006), for example, found that the models that included only the origin-age and destination-age interactions produced estimates that were nearly indistinguishable from the observed values in the complete ODA table. Interestingly, there tends to be very little difference between male and female migration patterns in analyses of internal migration, whereas for these international migration data, significant differences were found.

The above analyses provide us with some direction on how to proceed with the combining of migration flow data. First, we do not need to include the complete data to produce accurate results. In fact, based on our analyses of the available data and analyses of internal migration in other studies, we believe the following and relatively simple two-way interaction model should capture most of the international migration patterns between countries in the EU / EFTA:

$$n^{*}_{ijxy} = (T)(O_i)(D_j)(A_x)(S_y)(OD_{ij})(OA_{ix})(OS_{iy})(DA_{jx})(DS_{jy})(AS_{xy}), \quad i \neq j \tag{4}$$

with n^{*}_{ijxy} denoting an initial estimated set of migration flows, not constrained to any set of margins.

The modelling strategy is therefore to calculate the multiplicative components in Equation 4 for countries providing data, and to estimate the component values for countries not providing data. Unfortunately, at the time of this writing, the 2007 age- and sex-specific data were not available. However, as shown below, we believe this is not a major problem for the model expressed in Equation 4 as there are strong regularities exhibited in the age and sex patterns over time.

The following equations are used to estimate the initial (unconstrained) migration flows corresponding to the model in Equation 4.[11] The *T* component represents the total number of all migrants in the system,

$$T = \sum_{ijxy} n_{ijxy} = n_{++++} \ . \tag{5}$$

The main effect components, O_i, D_j, A_x, and S_y, represent proportions of all migration from each origin, to each destination, in each age group and by sex, respectively, i.e.,

$$O_i = \frac{\sum_{jxy} n_{ijxy}}{\sum_{ijxy} n_{ijxy}} = \frac{n_{i+++}}{n_{++++}} \ , \tag{6}$$

$$D_j = \frac{\sum_{ixy} n_{ijxy}}{\sum_{ijxy} n_{ijxy}} = \frac{n_{+j++}}{n_{++++}} , \tag{7}$$

[11] We used Excel for this.

$$A_x = \frac{\sum_{ijy} n_{ijxy}}{\sum_{ijxy} n_{ijxy}} = \frac{n_{++x+}}{n_{++++}}, \tag{8}$$

$$S_y = \frac{\sum_{ijx} n_{ijxy}}{\sum_{ijxy} n_{ijxy}} = \frac{n_{+++y}}{n_{++++}}, \tag{9}$$

The T, O_i and D_j components were obtained directly from the estimated origin-destination migration flow tables (see Section 3.2). The A_x components for the years 2002-2006 are presented in Figure 1. Here, we find strong regularities in the patterns over time with a downward slope in the child years and a labour force peak in the young adult years, corresponding to the 'standard' schedule of age-specific migration (Rogers et al., 2010, p. 20). The S_y components averaged 0.453 for females, with a minimum of 0.442 in 2003 and a maximum of 0.463 in 2005. Note, the A_x and S_y components represent the averages exhibited by the countries reporting data in the OAS and DAS tables provided by Eurostat.

----- Figure 1 about here -----

The two-way interaction components represent the ratios of observed migration to expected migration (for the case of no interaction) and are calculated as

$$OD_{ij} = \frac{n_{ij++}}{(T)(O_i)(D_j)}, \tag{10}$$

$$OA_{ix} = \frac{n_{i+x+}}{(T)(O_i)(A_x)}, \tag{11}$$

$$OS_{iy} = \frac{n_{i++y}}{(T)(O_i)(S_y)}, \tag{12}$$

$$DA_{jx} = \frac{n_{+jx+}}{(T)(D_j)(A_x)}, \tag{13}$$

$$DS_{jy} = \frac{n_{+j+y}}{(T)(D_j)(S_y)}, \tag{14}$$

$$AS_{xy} = \frac{n_{++xy}}{(T)(A_x)(S_y)}. \tag{15}$$

The OA_{ix}, DA_{jx} and AS_{xy} components represent the deviations from the overall age profile of migration, A_x. For estimation purposes, it is useful to know that they also represent ratios of the age compositions of emigration and immigration to the overall age composition of migration. Likewise, the OS_{iy} and DS_{jy} components represent the deviations from the overall proportions of migration in each sex group, S_y. For estimation purposes, these also represent ratios of the sex-specific proportions of emigration and immigration from and to each country, respectively, to the corresponding overall proportions.

Because of the large number of cells resulting from the estimation process (i.e., 32 x 31 x 18 x 2 = 17,858 cells for each of the six years), we focus our illustration of multiplicative components on four flows:

1) Norway to Sweden (good data sources),
2) Germany to Spain (reasonable data sources),
3) Poland to United Kingdom (poor data sources), and
4) France to Belgium (missing data).

The origin-age components (i.e., OA_{ix}) for Norway, Germany and Poland and the destination-age components (i.e., DA_{jx}) for Sweden, Spain and the United Kingdom are presented in Figure 2. Note the ratios for France and Belgium were set to equal one, as data for these countries were not available. The same assumption was used for all countries not providing data with the result that the patterns for these countries came from the main effects of age and sex. The OS_{iy} and DS_{jy}

components are presented in Table 5, and the AS_{xy} components are presented in Figure 3. In all three cases, only the female patterns are presented, as the male patterns exhibited the reciprocal patterns. For example, in Figure 3, we find that relatively more women migrate at young and old ages, whereas men are overrepresented in the 30-54 ages.

----- Table 5 and Figures 2-3 about here -----

The estimation of migration flows based on the multiplicative components produces "initial" estimates that need to be constrained to the estimated origin-destination migration flow totals.[12] This is done by including the initial values as an offset in the following log-linear model:

$$\ln(n_{ijxy}) = \lambda + \lambda_i^O + \lambda_j^D + \lambda_{ij}^{OD} + \ln(n_{ijxy}^*), \tag{16}$$

where n_{ijxy}^* denotes the offset of initial values, obtained by multiplying the multiplicative components together (i.e., Equation 4), and the lambda parameters represent the constraints in a log-linear model weighted to the origin-destination migration flow totals estimated previously (Section 3.2).

4. Results

In this section, we present some of our results from the models described in the previous section to estimate the missing marginal totals and origin-destination associations of the origin-destination matrices, and then the disaggregation of these tables by age and sex. The flows are estimated for the years 2002 to 2007. In our analysis, we first describe the changes over time in the aggregate flows and then show some of the estimated age and sex patterns.

[12] We used SPSS's log-linear procedure for this.

4.1 Changes over time

The harmonised estimates of immigration, emigration and net migration, averaged from 2002-2007 and ordered by level of immigration, are presented in Figure 4. On average, Germany received the largest number of immigrants with nearly 600 thousand per year. The United Kingdom, Italy, Spain and France were the next largest receivers. Of these countries, four had shares of migration from the rest of the world that exceeded 60 percent. However, most countries in the EU / EFTA (i.e., 19 out of 31), including Germany, had shares from the rest of the world not exceeding 50 percent, illustrating the importance of the EU / EFTA migration system.

----- Figure 4 about here -----

The largest senders of migrants on average were, again, Germany (440 thousand), followed by Poland (307 thousand), United Kingdom (296 thousand), Romania (273 thousand) and Spain (231 thousand). Of the five largest senders of migrants, only the United Kingdom and Spain had shares to the rest of the world exceeding 50 percent. In fact, most countries (24 out of 31) had estimated shares below 50 percent. In terms of average net migration, the top receivers of migrants also had the largest net migration totals, with rest of the world migration being most important. However, amongst these countries, note that Italy received the largest net gain, while Germany only ranked fourth, below the United Kingdom and Spain. The two countries with the largest negative net migration were Poland and Romania, where the negative numbers were attributed mostly to migration between EU / EFTA countries.

According to our estimates, migration between countries in the EU / EFTA increased steadily from 1.3 million in 2002 to 2.0 million in 2007. This increase is not necessarily surprising as the EU added 10 countries to its membership in 2004 and another two in 2007, all of which had substantially lower GDP levels than in the existing EU / EFTA countries. Another factor contributing to this increase, as suggested in the results below, is corresponding increases in the migration levels during the six years between countries in the EU15 (i.e., the EU countries before accession in 2004) and EFTA.

The EU15 countries and the EFTA countries (i.e., Iceland, Liechtenstein, Norway and Switzerland) were consistent net receivers of migrants gaining between 246 thousand and 390 thousand per year. The sources of these migrants were the 2004 and 2007 EU accession countries (A2004 and A2007, respectively). The ratios of emigration to immigration were very high for these 12 countries. In 2002, the A2004 countries sent two migrants to the EU15 and EFTA countries for every one they received. However, despite considerable increases in the levels of emigration, this ratio decreased to 15 migrants sent for every 10 received in 2007. One possible explanation for this is that accession to the EU facilitated more return migration. The corresponding ratios for the A2007 countries (i.e., Romania and Bulgaria) were even greater, i.e., between 3.7 and 4.8 during the six year period.

----- Table 6 about here -----

Relative to migration from the rest of the world, EU15 countries received smaller shares of migrants from EU / EFTA countries, whereas EFTA, A2004 and A2007 countries received (slightly) larger shares (see Table 6). In terms of emigration, all four groups of countries exhibited larger shares going to EU / EFTA countries relative to the rest of the world. Finally, in terms of overall changes in the levels over time, we found the largest increases to have occurred within the EU / EFTA area. Here, the immigration and emigration levels increased by 56 percent, whereas migration from the rest of the world only increased by 28 percent. In terms of numbers, immigration from EU / EFTA countries increased by 719 thousand, whereas immigration from the rest of the world increased by 512 thousand. Thus, less than half of the increase in immigration between 2002 and 2007 came from outside the EU / EFTA. The main drivers of this increase were most likely the EU accessions of ten countries in 2004 and two more in 2007. Migration from the A2004 countries to the EU / EFTA increased by 63 percent from 2002 to 2007, whereas the migration to the rest of the world remained about the same (with the exception of 2006). The A2007 countries exhibited a sharp increase in migration to EU / EFTA countries between 2002 and 2003 and then levelled off until another increase in 2007. The first increase in the patterns is surprising particularly since emigration to the rest of the world did not increase and emigration from the A2007 countries increased only slightly. The second increase, on the other hand, conforms to our expectations in relation to the accession that occurred in 2007. Likewise, the results confirm our expectations regarding the A2004 countries joining the EU in 2004, where emigration steadily increased in 2004 and thereafter. Note that there were corresponding increases in the immigration to A2004 and A2007 countries from EU / EFTA countries (i.e., return migration), albeit at lower levels.

In comparison to the reported numbers provided by Eurostat, our results have several implications as shown by the net migration totals in Table 7. First, our estimated net migration totals for the EU / EFTA countries are considerably lower than Eurostat's figures, even with missing data considered. For example, in 2007, we estimated the net migration for EU / EFTA countries to be 864 thousand. The corresponding figure from Eurostat is 2089 thousand. One likely explanation for this is that emigration statistics have much higher levels of underreporting relative to immigration statistics. Second, our estimates resulted in opposite net migration totals for several countries. Cyprus, Czech Republic, Hungary, Liechtenstein, Malta and Slovakia all reported positive net migration totals between 2002 and 2007, whereas in most of these cases, we estimate negative totals. Third, for some countries, we estimate considerably different net migration totals. These include the much lower estimates for Portugal, Spain and Slovenia and the much higher estimates for Latvia, Poland and Romania. Finally, we have produced estimates for countries who have not given migration data to Eurostat. These include figures for Belgium, Bulgaria, Estonia and Ireland.

----- Table 7 about here -----

4.2 Age and sex patterns

The average age patterns of migration are presented in Figure 1 (as main effects) for the years 2002-2006. In Figure 5, we present our estimates of age-specific net migration totals by sex for the EU15, EFTA, A2004 and A2007 countries. Interestingly, our estimates produce different patterns for each group. The estimates for the EU15 countries resulted in higher (positive) net migration totals of female migrants in the 20-24 and 25-29 age groups, whereas for the EFTA countries, there were considerably more males in the 25-59 ages. For the A2004 countries, the age-specific net migration patterns of females and males were nearly identical and mostly negative. The exceptions are the first age group and the 55-79 ages, which mostly likely reflects the age compositions of return migrants. Finally, for the A2007 countries, the estimated totals of net migration were much higher for females, at all ages, than for males.

----- Figure 5 about here -----

To illustrate some of the detailed age- and sex-specific migration estimates, we have selected the same four flows as in Section 3.3 to present estimates between countries with good data (i.e., Norway to Sweden), reasonable data (i.e., Germany to Spain), poor data (i.e., Poland to the United Kingdom) and missing data (i.e., France to Belgium). In Figure 6, we present the results for these flows by age and sex for 2002 and 2007. The main differences found in the Norway to Sweden flow are the lower levels of migration in the child to young adult age groups in 2007 in comparison to 2002. Between 2002 and 2007, large increases in the levels of 20-54 year old migration were estimated for both the Germany to Spain and France to Belgium flows. In both cases, females also exhibited much higher levels of migration than males. The estimated Poland to the United Kingdom flows exhibited similar levels by age for males and females. The increase in the levels was largely due to two age groups, 20-24 and 25-29 year olds.

----- Figure 6 about here -----

5. Conclusion

In this paper, we have developed a methodology to estimate a complete set of migration flows by age and sex between all 31 countries in the EU / EFTA. To do this, we had to combine four pieces of information: a previously harmonised origin-destination migration flow table representing flows between 19 EU / EFTA countries (de Beer et al. 2010), an incomplete emigration by age by sex table, an incomplete immigration by age by sex table, and covariate information. The result is a synthetic data base that can be used for many purposes.

A selection of our results has been presented to give an idea of the detail in our estimates.[13] While these estimates are by no means perfect, we believe they provide a substantial and significant improvement over the patterns exhibited in the reported flows, which contain inconsistencies due to measurement, collection and availability. In general, the estimated patterns coincide with what we would expect based on migration theory. For instance, the largest estimated flows are between countries with the largest populations, more migration is observed between neighbouring countries than non-neighbouring countries, and net receivers of migrants are those with higher GDP levels. Our estimates also reflect increases in the levels of migration associated with the expansion of countries in the EU.

The contributions of this paper are many. First, we have expanded the estimates in de Beer et al. (2010) to include missing flows, and thus completing the matrix of flows between EU / EFTA countries. This involved developing models for the estimation of total immigration and emigration and for the estimation of the associations between origins and destinations. Second, we have developed a model and a set of assumptions for disaggregating these flows by age and sex based on incomplete information. Third, we have shown how our results can be used to better understand the migration patterns in the EU / EFTA. Fourth, we have compared our estimates against reported

[13] The complete set of results is available at http://www-oud.nidi.knaw.nl/en/projects/230211/.

values and identified where important differences arise. In combination with the harmonisation methodology developed in de Beer et al. (2010), we believe our methodology and resulting estimates can be used to improve current population estimation methods. Finally, we have provided a base for countries to improve their statistics on migration as required in the 2007 Regulation on migration statistics passed by the European Parliament. Our methodology is based on the idea of combining data. Countries could benefit from this approach, at the very least, by comparing their reported figures of, say, immigration from Germany with Germany's emigration figures. However, this will only help, if the user knows that Germany applies a relatively loose definition of migration and therefore its figures are higher than those using, say, a six month or twelve month definition.

While we believe we have produced six years of reasonable estimates of migration flows, they are by no means without error. The estimates are based on a hierarchical methodology. First the available origin-destination-specific data are harmonised based on reports by sending and receiving countries, then the missing data are estimated by using covariates, and finally the flows are disaggregated into age and sex based on the patterns exhibited by countries providing data. Further improvements could be made to integrate the various steps. Also, there are no measures of uncertainty associated with our estimates. It would be useful to know which of our estimated flows are considered to be very reliable and which are akin to rough guesses. However, we believe we have made an important start towards the improvement of providing usable migration statistics to the community. In fact, work has already started on the next stage of modelling, namely the Integrated Modelling of European Migration (IMEM) project recently funded by New Opportunities for Research Funding Agency Co-operation in Europe (NORFACE). Over the next couple of years, this project aims to integrate the harmonisation and estimation of missing data into a single (Bayesian) model that also includes measures of uncertainty and expert judgements.[14] We hope this work provides an important foundation for work such as this and others aiming to improve our knowledge and understanding of the complexity in international migration.

[14] See http://www.norface.org/migration12.html.

In conclusion, the methodology we have presented in this paper for estimating international migration flows is the first of its kind. We have overcome major obstacles concerning inconsistencies in the reported data and completely missing data to produce what we believe are very reasonable estimates of detailed flows over time. In fact, we believe our estimates are much better than those currently reported in, say, the Eurostat database. These estimates provide a complete and more consistent picture of population movements occurring in Europe. The approach is based on a closed system of movements, that is, an emigrant from one place must be an immigrant to another. The methodology is flexible to account for various types of migration data, as well as other categorical information, such as flows by broad citizenship groups or education levels. The data can be used for many purposes, including to improve our understanding of recent patterns of migration, as inputs into population projections, to compare against reported figures and to test any estimation procedure countries may adopt for improving the reporting of their statistics. Most importantly, we have shown that it is not impossible to overcome the complex nature of international migration data to produce reasonable estimates of migration based on information from multiple sources.

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Table 1. Reported flows of migration between selected countries in the European Union, 2003

From		BE	CZ	DK	DE	EE	GR	ES	FR	IE	IT
BE	R	n.a.	80	587	4,291	…	…	3,037	…	…	1,959
	S	n.a.	…	…	…	…	…	…	…	…	…
CZ	R	…	n.a.	232	9,258	…	…	388	…	…	915
	S	78	n.a.	47	950	2	66	70	283	31	197
DK	R	…	65	n.a.	2,693	…	…	764	…	…	281
	S	511	180	n.a.	2,540	133	229	1,720	1,333	264	782
DE	R	…	1,228	3,221	n.a.	…	…	13,746	…	…	12,902
	S	4,623	8,909	2,712	n.a.	597	18,106	16,236	19,060	2,415	33,802
EE	R	…	4	169	947	n.a.	…	60	…	…	103
	S	…	…	…	…	n.a.	…	…	…	…	…
GR	R	…	57	278	12,959	…	n.a.	273	…	…	638
	S	…	…	…	…	…	n.a.	…	…	…	…
ES	R	…	103	1,665	14,647	…	…	n.a.	…	…	2,051
	S	647	34	130	2,109	4	38	n.a.	2,474	487	801
FR	R	…	462	1,488	18,133	…	…	8,847	n.a.	…	4,647
	S	…	…	…	…	…	…	…	n.a.	…	…
IE	R	…	45	306	2,046	…	…	1,649	…	n.a.	292
	S	…	…	…	…	…	…	…	…	n.a.	…
IT	R	…	274	895	23,702	…	…	5,796	…	…	n.a.
	S	1,414	20	155	9,778	1	211	895	2,933	130	n.a.

Columns: To

Notes: R = receiving country's reported flows; S = sending country's reported flow; … = no reported data available; ; n.a. = not applicable; BE = Belgium, CZ = Czech Republic, DK = Denmark, DE = Germany, EE = Estonia, GR = Greece, ES = Spain, FR = France, IE = Ireland and IT = Italy.

Table 2. Regression coefficients for models predicting the natural logarithm of total harmonised immigration and emigration flows for 19 countries in the EU / EFTA, 2002-2007

	Coefficients				Standard Error			
	Immigration		Emigration		Immigration		Emigration	
	EU/ EFTA	Rest of World	EU/ EFTA	Rest of World	EU/ EFTA	Rest of World	EU/ EFTA	Rest of World
Constant	*-3.573*	-13.005	10.365	*6.223*	*2.164*	2.629	1.739	*3.964*
ln(population)	0.919	1.163	0.869	0.935	0.037	0.045	0.030	0.068
Percent 65+	-0.188	-0.076	-0.236	-0.182	0.028	0.034	0.022	0.051
Life expectancy (females)	0.081	0.168	-0.070	*-0.031*	0.029	0.035	0.023	*0.053*
GDP per capita (EU27 = 100)	0.008	*-0.002*	0.005	-0.006	0.001	*0.002*	0.001	0.002
Percent urban	0.010	*0.008*	0.008	*0.013*	0.004	*0.005*	0.003	*0.007*
2003 (indicator)	*0.119*	*0.029*	*0.062*	*0.053*	*0.148*	*0.179*	*0.119*	*0.270*
2004 (indicator)	*0.270*	*0.029*	*0.207*	*0.142*	*0.148*	*0.180*	*0.119*	*0.271*
2005 (indicator)	0.401	*0.049*	0.304	*0.239*	0.149	*0.181*	0.119	*0.272*
2006 (indicator)	0.483	*0.096*	0.416	*0.403*	0.150	*0.182*	0.120	*0.274*
2007 (indicator)	0.659	*0.115*	0.530	*0.413*	0.150	*0.183*	0.121	*0.275*
Germany (indicator)	0.507	*-0.383*	0.802	*0.499*	0.216	*0.262*	0.173	*0.395*
R^2	0.90	0.92	0.91	0.75				

Notes: Italics = not significant at 0.05 level; Number of observations = 114.

Table 3. Coefficients from regression to predict the natural logarithm of origin-destination association terms (OD_{ij}), 2002-2007 average

Variable	B	Std. Error	Sig.
(Constant)	-0.4900	0.2416	0.0426
Contiguity	0.5501	0.0684	0.0000
Accession dummy	0.9980	0.1545	0.0000
Language family	0.1002	0.0705	0.1549
ln GNI PPP ratios	0.1300	0.0157	0.0000
ln Distance	0.0405	0.0339	0.2316
ln Foreign-born association	0.2471	0.0123	0.0000
ln Trade association	0.3291	0.0201	0.0000

Table 4. Estimated origin-destination association terms (OD_{ij}) for the flows between the 19 countries with data and the 12 countries with missing data, 2007

	Destination																
Origin	AT	CY	CZ	DE	DK	ES	FI	IS	IT	LT	LU	LV	NL	NO	PL	SE	S
AT		0.18	0.73	1.53	0.47	0.15	0.48	0.23	0.36	0.12	0.10	0.37	0.50	0.17	1.04	0.47	8
CY	0.09		0.09	0.10	0.14	0.01	0.35	0.00	0.04	0.16	0.00	0.29	0.18	0.07	0.13	0.36	0
CZ	1.35	0.63		0.87	0.51	0.19	0.32	0.50	0.38	0.28	0.12	1.24	0.58	0.28	0.31	0.39	0
DE	1.81	0.16	0.34		0.79	0.32	0.39	0.18	0.63	0.63	0.80	0.46	0.89	0.54	3.06	0.64	2
DK	0.29	0.22	0.22	0.52		0.37	2.70	18.80	0.25	2.05	0.23	2.45	0.84	7.36	0.39	17.33	0
ES	0.20	0.05	0.04	0.40	0.67		0.73	0.11	0.25	1.11	0.10	0.24	0.79	0.27	0.18	0.52	0
FI	0.86	0.36	0.33	0.81	2.22	0.60		0.98	0.41	0.64	0.25	2.34	1.24	3.63	0.13	13.97	0
IS	0.26	0.00	0.11	0.22	28.34	0.30	2.23		0.19	2.41	0.20	2.63	0.92	4.94	0.78	7.05	0
IT	0.81	0.11	0.30	1.01	0.76	0.90	0.56	0.30		0.47	0.53	0.59	0.84	0.19	0.90	0.53	2

LT	0.32	0.33	0.23	0.81	3.38	0.91	0.54	5.18	0.37		0.10	11.47	0.55	6.06	0.52	2.45	0
LU	0.23	0.05	0.02	1.14	0.82	0.09	0.92	0.60	0.37	0.45		0.07	0.50	0.07	0.10	0.50	3
LV	0.36	2.51	0.17	0.92	3.91	0.31	2.29	4.94	0.46	8.95	0.00		0.61	3.09	0.20	2.63	0
NL	0.56	0.23	0.43	0.98	0.90	0.66	0.71	0.22	0.30	0.38	0.34	0.65		0.90	0.68	1.21	0
NO	0.21	0.16	0.15	0.35	9.88	0.84	5.77	4.18	0.20	3.69	0.13	2.33	0.92		0.71	15.78	0
PL	0.62	0.46	0.52	2.05	1.02	0.22	0.22	3.18	0.58	0.14	0.10	0.30	1.07	2.39		1.35	0
SE	0.36	0.44	0.18	0.36	6.73	0.39	13.36	3.64	0.20	1.53	0.33	1.84	0.68	8.74	0.73		1
SI	4.99	0.32	0.32	1.02	0.70	0.22	0.41	0.73	1.24	0.17	0.54	0.30	0.82	0.39	0.08	0.78	
SK	1.47	0.93	15.81	0.45	0.21	0.07	0.07	0.22	0.16	0.02	0.02	0.07	0.25	0.36	0.05	0.10	0
UK	0.26	3.20	0.27	0.29	1.00	1.67	0.85	0.32	0.48	4.10	0.15	2.49	1.10	0.54	0.54	1.06	0
BE	0.29	0.22	0.18	0.44	0.72	0.69	0.90	0.12	0.80	0.50	11.59	0.40	5.71	0.26	0.54	0.60	1
BG	2.84	3.88	2.97	3.17	0.66	5.47	0.71	0.07	2.15	0.51	0.08	8.35	5.84	0.39	0.31	2.27	0
CH	1.51	0.22	0.33	1.52	1.01	1.14	1.26	0.21	3.82	0.31	0.37	0.33	0.96	0.40	0.41	1.04	13
EE	0.28	1.01	0.14	0.50	2.05	0.17	78.76	1.01	0.32	1.22	0.00	14.98	0.50	3.58	0.08	4.32	0
FR	0.20	0.12	0.17	0.43	0.50	0.52	0.31	0.09	0.45	0.15	3.69	0.21	0.64	0.23	0.39	0.41	0
GR	0.62	34.58	0.22	1.66	0.61	0.19	0.69	0.05	0.54	0.27	0.16	0.18	1.87	0.22	0.90	1.90	0
HU	3.52	0.71	0.11	2.02	0.61	0.14	0.81	0.11	0.26	0.02	0.07	0.03	0.73	0.25	0.09	1.01	0
IE	0.07	0.17	0.07	0.10	0.22	0.19	0.32	0.05	0.09	4.98	0.13	3.58	0.27	0.09	0.46	0.26	0
LI	2.87	0.00	0.09	0.44	1.45	0.28	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.29	0.45	0.00	20
MT	0.17	0.86	0.05	0.14	0.26	0.04	0.23	0.20	0.51	0.37	0.00	0.00	0.35	0.09	0.04	0.55	0
PT	0.44	0.11	0.08	0.98	0.58	3.98	0.36	1.86	0.33	0.75	15.31	0.49	2.64	0.36	0.08	0.44	0
RO	3.09	0.98	0.46	1.69	0.47	7.34	0.27	0.10	9.45	0.02	0.07	0.40	0.72	0.29	0.03	1.28	0

Note: Missing data estimates are based on the harmonised data of 19 EU / EFTA countries pooled from 2002 to 2007.

Table 5. Origin-sex (OS_{iy}) and destination-sex (DS_{jy}) components of female migration, 2002-2006

	Origin-Sex (OS_{iy})					Destination-Sex (DS_{jy})				
Country	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006
AT	**0.914**	**0.914**	0.914	0.876	0.889	**1.026**	**1.026**	1.026	1.021	1.021
BE										
BG										
CH	1.063	1.082	1.051	1.024	1.037	1.095	1.093	1.101	1.084	1.071
CY	1.153	1.447	1.508	1.430	1.503	1.201	1.048	1.188	1.288	1.435
CZ	0.694	0.691	0.667	0.855	**0.855**	0.846	0.755	0.810	0.846	0.846
DE	0.828	0.845	0.826	0.819	0.838	0.952	0.948	0.944	0.952	0.922
DK	1.053	1.077	1.050	1.031	1.027	1.114	1.101	1.127	1.128	1.098
EE										
ES	1.137	1.038	0.973	0.946	0.924	1.054	1.056	1.029	1.046	1.079
FI	1.129	1.172	1.101	1.106	1.097	1.107	1.113	1.139	1.121	1.099
FR										
GR										
HU	1.010	1.016	**1.000**	0.824	0.799	0.989	0.939	1.104	0.985	1.025
IE										
IS	1.084	**1.084**	**1.084**	**1.084**	**1.084**	1.144	**1.144**	**1.144**	**1.144**	**1.144**
IT	0.971	0.996	**0.996**	**0.996**	**0.996**	1.127	1.128	**1.128**	**1.128**	**1.128**
LI										
LT	1.072	1.202	1.167	1.112	1.123	0.997	1.000	1.057	0.997	0.991
LU	0.995	1.080	0.958	0.898	0.943	1.018	1.035	1.014	1.036	**1.036**
LV	1.020	1.137	1.114	1.203	1.158	0.951	0.747	0.915	0.990	1.032
MT						0.947	**0.947**	**0.947**	**0.947**	**0.947**
NL	1.037	1.067	1.045	1.027	1.046	1.083	1.103	1.154	1.139	1.112
NO	1.073	1.068	1.070	1.056	**1.056**	1.149	1.133	1.160	1.134	**1.134**

PL	**0.918**	**0.918**	**0.918**	**0.918**	0.918	**1.024**	**1.024**	**1.024**	**1.024**	1.024
PT						1.178	1.175	1.240	**1.240**	**1.240**
RO	1.212	1.327	1.374	1.349	1.364	1.068	1.031	0.985	0.976	0.871
SE	1.061	1.101	1.055	1.014	1.023	1.089	1.110	1.143	1.110	1.070
SI	1.132	1.121	0.995	1.139	1.123	0.709	0.728	0.599	0.592	0.485
SK	1.425	0.915	0.917	1.140	1.042	0.981	0.902	0.887	0.824	0.827
UK	1.047	0.962	1.091	**1.000**	**1.000**	1.071	1.263	1.157	1.073	1.057
REST										

Notes: (1) Boldface denotes estimated; (2) the corresponding male patterns are (basically) the reciprocals of these ratios.

Table 6. Harmonised estimates of immigration and emigration (in thousands) for countries in the EU15, EFTA, A2004 and A2007: 2002-2007

	Immigration					Emigration				
Year	EU15	EFTA	A2004	A2007	Total	EU15	EFTA	A2004	A2007	Total
	A. From EU / EFTA countries					B. To EU / EFTA countries				
2002	1,002	90	149	46	1,286	766	80	297	143	1,286
2003	1,158	87	165	53	1,462	810	79	318	255	1,462
2004	1,226	87	205	55	1,573	867	79	384	244	1,573
2005	1,233	90	236	58	1,617	891	79	428	219	1,617
2006	1,353	106	268	67	1,795	984	85	481	245	1,795
2007	1,452	145	327	80	2,005	1,125	89	486	305	2,005
	C. From rest of world					D. To rest of world				
2002	1,560	72	141	44	1,817	656	25	317	96	1,093
2003	1,837	65	164	46	2,112	716	24	304	95	1,139
2004	1,865	67	176	48	2,155	721	27	312	97	1,157
2005	1,705	66	198	50	2,017	758	28	287	102	1,176
2006	1,841	64	226	53	2,183	921	30	406	114	1,471
2007	1,909	77	287	55	2,329	1,014	28	312	111	1,465
	E. From all countries					F. To all countries				
2002	2,562	162	290	90	3,104	1,421	105	614	239	2,380
2003	2,995	152	328	99	3,575	1,526	103	622	350	2,601
2004	3,090	154	381	103	3,728	1,587	106	696	341	2,730
2005	2,938	156	433	108	3,634	1,649	107	715	321	2,793
2006	3,194	170	494	120	3,978	1,905	114	887	360	3,266
2007	3,361	222	615	136	4,334	2,139	117	799	416	3,470

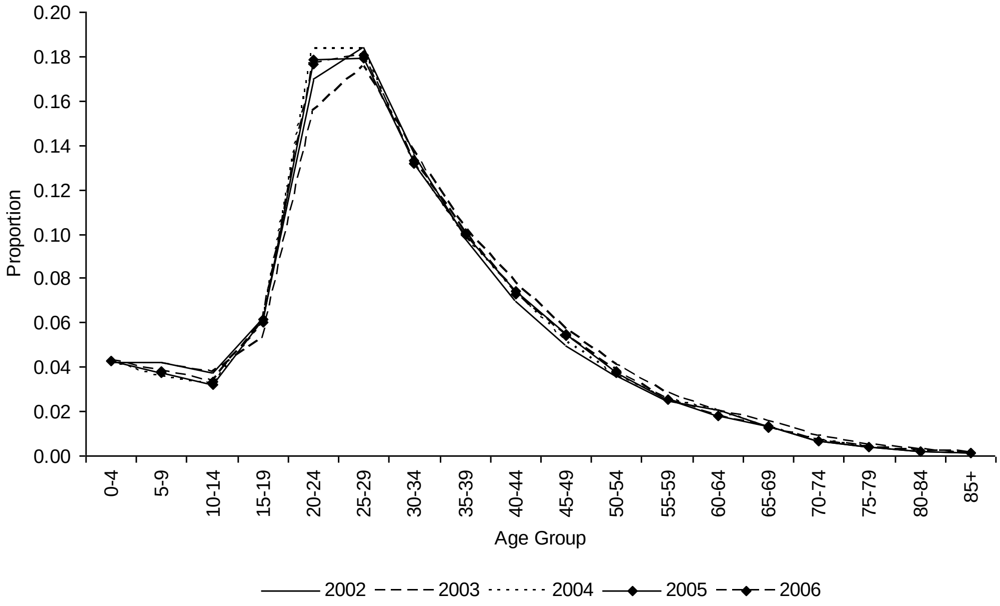
Notes: EU15 = 15 countries present in the European Union prior to May 2004; EFTA = Iceland, Lichtenstein, Norway and Switzerland, countries in the European Free Trade Association; A2004 = 10 countries who joined the European Union in 2004; A2007 = Bulgaria and Romain, countries who joined the European Union in 2007.

Table 7. Comparison of net migration totals provided by Eurostat and our harmonised estimates: EU / EFTA countries 2004-2007

	Reported by Eurostat				Our Estimates			
Country	2004	2005	2006	2007	2004	2005	2006	2007
AT	50.6	50.3	27.5	32.7	61.4	57.3	28.9	35.1
BE	43.3	N/A	N/A	55.4	30.5	35.1	44.2	48.5
BG	N/A	N/A	N/A	-1.4	-30.1	-29.6	-33.7	-53.5
CH	40.5	33.9	39.4	75.5	40.5	36.2	39.4	75.5
CY	15.7	14.4	8.7	7.6	-11.2	-24.4	-19.1	-34.9
CZ	18.6	36.2	34.7	83.9	-100.9	-36.9	-74.2	68.3
DE	82.5	95.0	22.8	43.9	145.1	128.7	78.6	48.4
DK	4.8	6.6	10.0	23.1	5.0	6.0	7.3	14.5
EE	N/A	N/A	N/A	N/A	-5.2	-5.8	-6.5	-7.0
ES	629.5	651.3	698.5	731.2	276.9	274.2	205.2	110.4
FI	6.7	9.0	10.3	13.6	8.9	11.4	12.5	16.3
FR	109.0	97.5	93.6	71.0	99.1	107.2	139.7	155.0
GR	41.4	40.0	40.0	41.0	25.0	26.3	28.5	28.5
HU	18.2	17.3	17.9	19.9	-18.3	-22.7	-25.6	-28.6
IE	N/A	N/A	64.4	46.2	15.1	19.6	32.3	24.6
IS	0.5	3.9	5.3	3.1	0.1	0.8	1.3	1.5
IT	379.7	260.6	222.4	491.5	496.9	329.5	389.1	381.6
LI	0.1	0.1	0.1	0.1	-0.1	-0.1	0.1	0.2
LT	-9.6	-8.8	-4.9	-5.2	-17.4	-15.5	-11.5	-11.2
LU	4.4	6.1	5.4	6.0	6.5	6.5	4.9	4.7
LV	-1.1	-0.6	-2.5	-0.6	-11.5	-9.4	-17.8	-10.9
MT	1.0	0.1	-0.1	1.7	-1.6	-1.3	-1.8	-1.5
NL	19.0	9.2	10.1	25.5	18.1	7.9	10.0	23.9
NO	13.2	18.4	23.7	39.7	8.0	11.8	15.4	28.4

PL	-9.4	-12.9	-36.1	-20.5	-118.9	-154.5	-239.7	-131.8
PT	47.2	38.4	26.1	19.5	3.1	4.8	7.7	7.4
RO	-10.1	-7.2	-6.5	0.7	-207.5	-183.9	-206.1	-226.6
SE	25.4	27.1	50.8	54.1	24.7	26.0	52.2	54.8
SI	1.9	6.7	6.3	14.3	1.1	2.0	1.2	0.5
SK	2.9	3.4	9.5	6.8	-31.6	-13.5	2.5	-26.8
UK	222.6	220.0	159.5	209.1	286.6	248.0	247.6	268.2
Total	1748.6	1616.1	1537.0	2089.3	998.2	841.6	712.5	863.7

Notes: N/A = not available from Eurostat’s website (as of 17 August 2010).



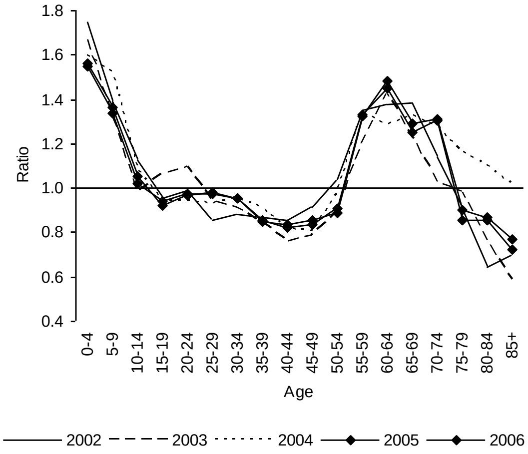
Note: Proportions based on available data.

Figure 1. The age main effect component of (A_x) migration, 2002-2006

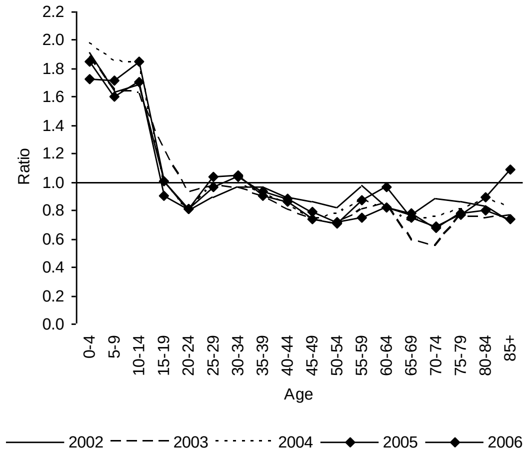
Origin-Age Components

Destination-Age Components

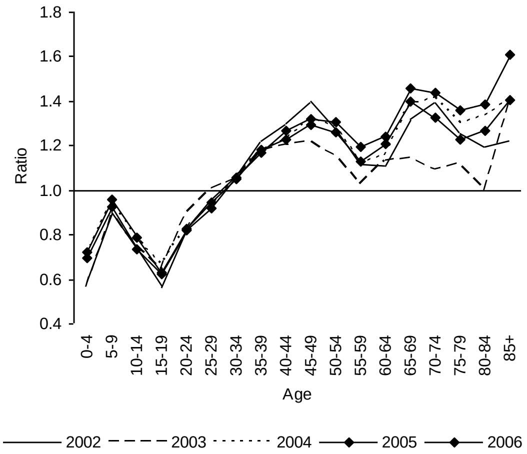
Norway



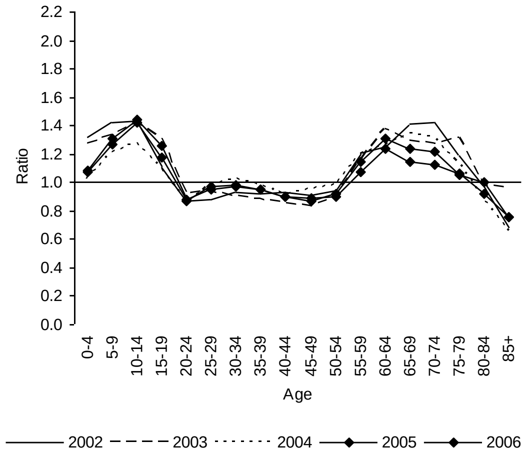
Sweden



Germany



Spain



Poland

United Kingdom

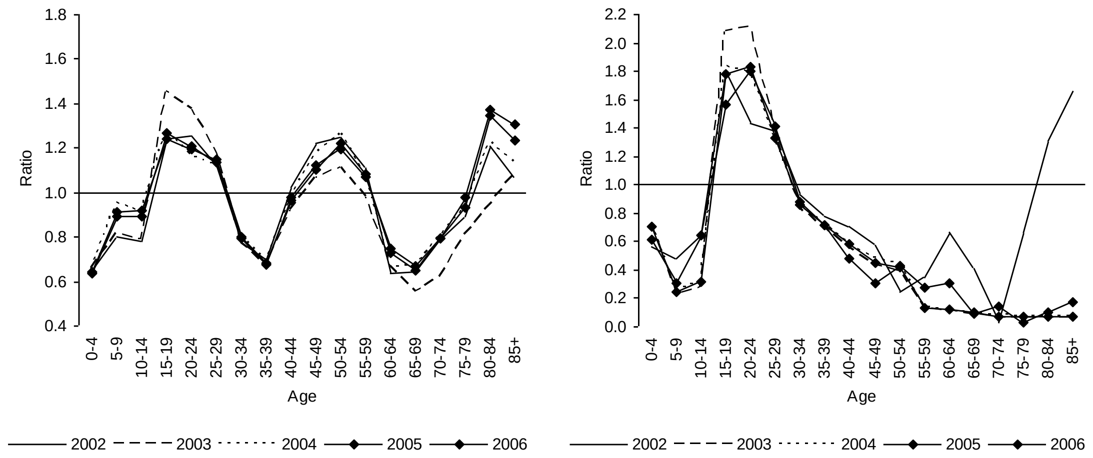


Figure 2. Selected origin-age (OA_{ix}) and destination-age (DA_{jx}) components of migration, 2002-2006

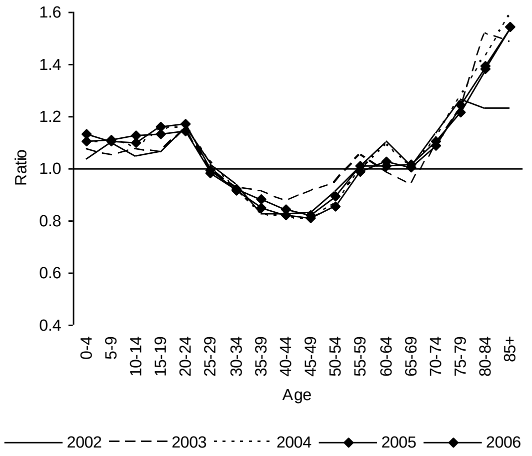
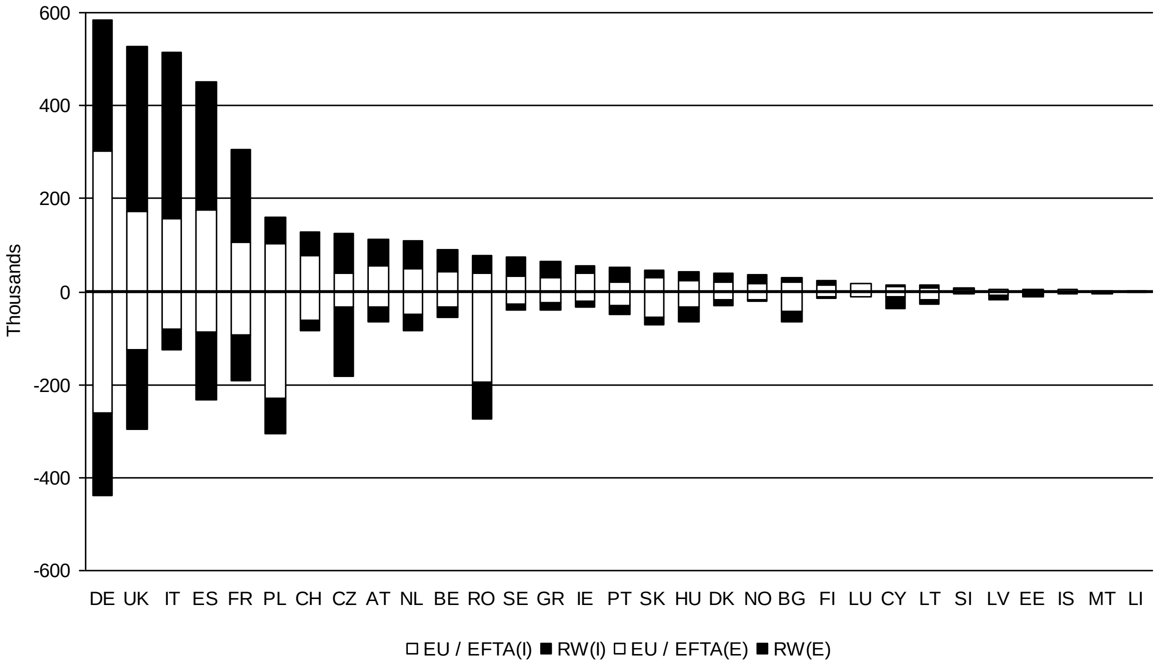


Figure 3. Age-sex components (AS_{xy}) of female migration, 2002-2006

A. Immigration and emigration



B. Net migration

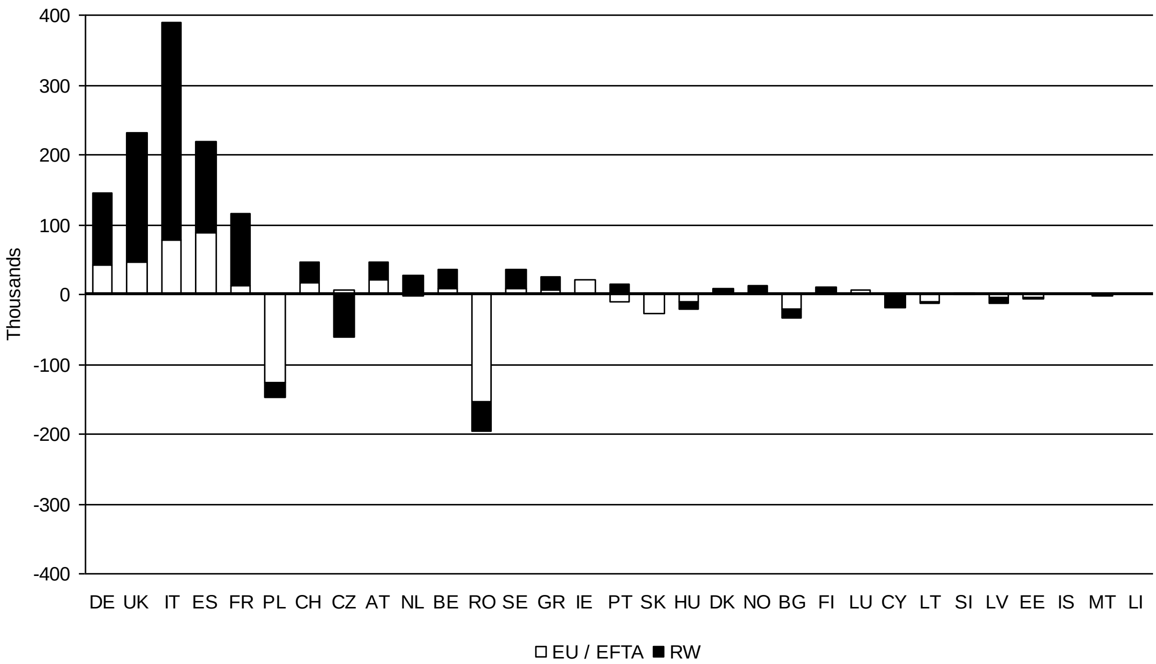
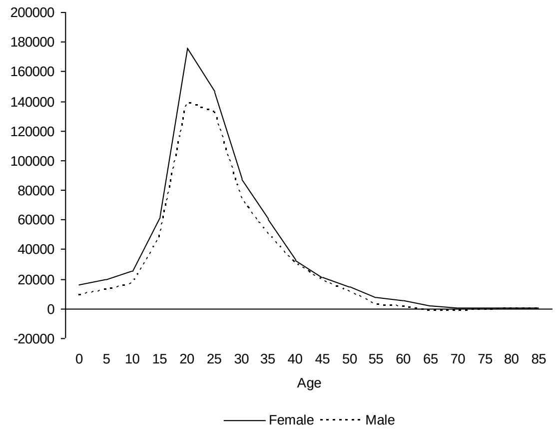
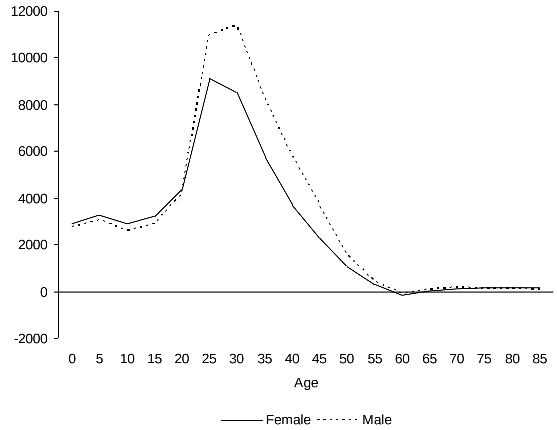


Figure 4. Harmonised immigration, emigration and net migration (in thousands) for EU / EFTA countries, average 2002-2007

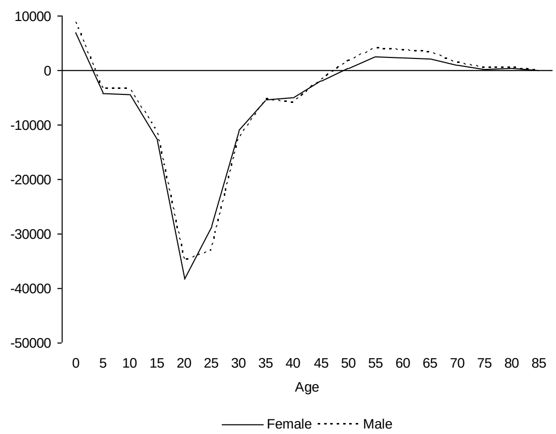
A. EU15 Countries



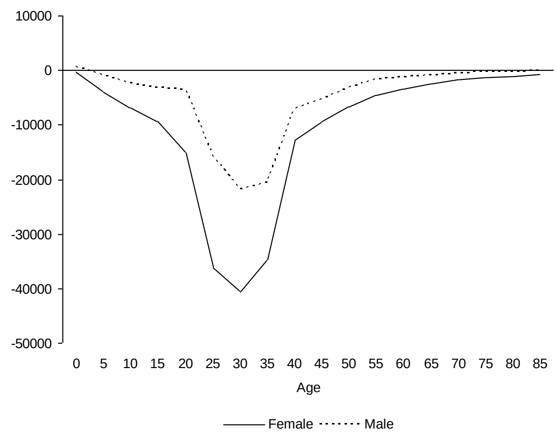
B. EFTA Countries



C. A2004 Countries



D. A2007 Countries



Notes: EU15 = 15 countries present in the European Union prior to May 2004; EFTA = Iceland, Lichtenstein, Norway and Switzerland, countries in the European Free Trade Association; A2004 = 10 countries who joined the European Union in 2004; A2007 = Bulgaria and Romain, countries who joined the European Union in 2007.

Figure 5. Estimated net migration totals for EU15, EFTA, A2004 and A2007 countries by sex, 2007

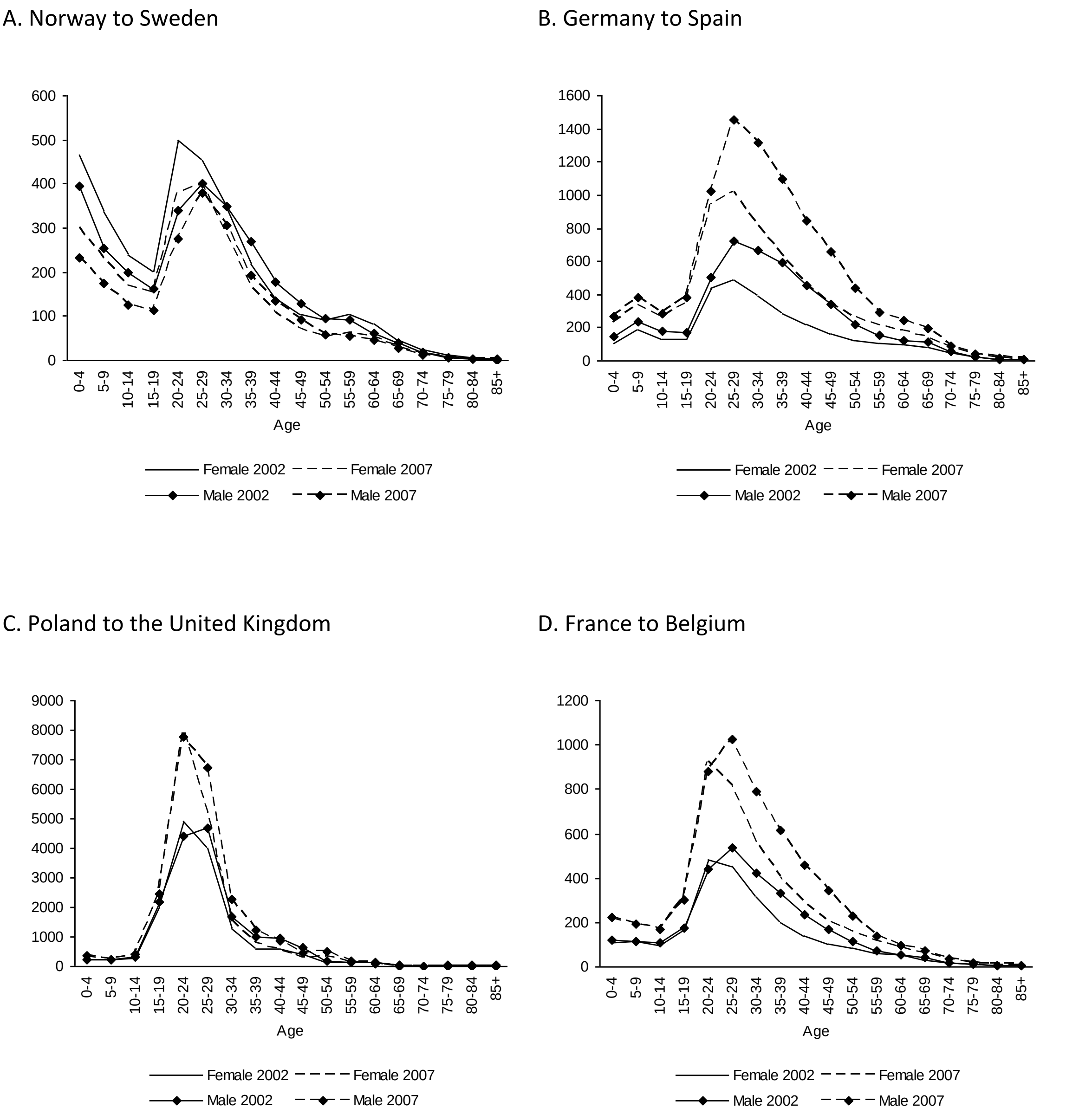


Figure 6. Selected estimates of migration flows between two countries with good data (Norway to Sweden), reasonable data (Germany to Spain), poor data (Poland to the United Kingdom) and missing data (France to Belgium) by age and sex, 2002 and 2007

Appendix 1. Harmonised estimates of immigration by country (in thousands) and area of origin, 2002-2007

	EU / EFTA						Rest of World					
Country	2002	2003	2004	2005	2006	2007	2002	2003	2004	2005	2006	2007
AT	36.8	43.8	55.7	60.1	59.5	68.7	58.4	62.3	68.2	65.3	47.7	47.4
BE	34.2	35.8	37.1	41.1	50.3	53.9	39.7	41.1	46.0	49.6	55.5	59.9
BG	17.3	19.0	19.8	19.2	20.7	22.8	10.4	10.9	11.8	12.1	12.5	12.6
CH	73.4	71.4	69.5	69.2	79.5	107.1	52.7	48.4	50.7	49.1	48.1	58.5
CY	7.4	8.6	11.3	12.6	8.0	9.8	4.4	5.1	6.7	7.5	4.8	5.8
CZ	28.0	37.6	33.5	37.8	42.7	65.4	58.6	78.8	70.2	79.1	89.5	137.1
DE	285.6	271.6	299.8	312.1	314.3	337.9	390.4	336.5	296.1	248.8	211.6	208.5
DK	18.8	18.3	19.2	20.4	23.1	26.6	18.1	17.1	16.4	16.9	17.4	19.6
EE	2.3	1.8	2.9	2.4	2.8	2.7	1.8	1.8	2.0	2.1	2.2	2.2
ES	116.8	161.8	165.1	173.4	202.3	230.3	183.0	254.6	259.3	272.4	318.5	362.9
FI	12.3	12.5	13.7	14.5	15.0	16.6	9.1	8.5	10.3	10.9	11.5	14.3
FR	88.4	90.6	97.6	105.1	124.9	134.4	164.3	168.2	181.2	195.3	232.0	249.6
GR	29.9	27.3	30.2	30.4	30.9	32.0	31.1	32.2	32.8	34.5	36.0	36.9
HU	21.3	21.1	23.3	24.6	25.4	27.2	17.2	17.3	18.3	18.5	20.4	20.6
IE	32.2	31.5	33.4	39.2	55.5	50.6	11.4	12.4	13.1	14.2	15.8	17.2
IS	1.9	2.6	3.2	3.8	4.4	5.3	0.6	0.6	0.8	0.9	1.1	0.9
IT	100.6	205.2	177.3	143.3	155.5	155.0	223.7	453.9	441.5	312.6	357.9	357.9
LI	0.2	0.2	0.3	0.2	0.4	0.5	0.1	0.1	0.1	0.1	0.1	0.1
LT	2.3	2.8	5.8	8.4	9.3	10.4	8.7	7.4	5.9	6.2	7.3	8.1
LU	15.9	16.5	16.9	17.7	15.1	16.3	0.8	0.8	0.7	0.8	0.8	0.8
LV	1.4	1.6	2.6	3.3	4.3	7.4	2.5	2.3	2.0	2.0	3.5	2.4
MT	1.3	1.3	1.2	1.4	1.6	1.6	1.1	1.1	1.1	1.3	1.2	1.4
NL	42.3	40.0	44.1	45.9	52.9	66.0	84.3	69.2	54.8	51.0	53.4	56.6
NO	14.4	13.0	14.1	16.7	21.9	32.3	18.3	16.2	15.4	15.6	15.0	17.6
PL	70.8	75.7	102.0	100.6	115.9	160.9	37.2	39.8	53.6	52.9	61.0	84.7
PT	18.8	18.7	19.2	19.8	24.2	28.6	27.3	28.1	30.2	32.5	36.1	35.5
RO	28.9	33.7	35.5	39.0	46.6	57.6	33.9	35.6	36.0	37.5	40.0	42.5

SE	29.6	29.0	29.4	31.1	39.1	45.5	34.4	34.4	32.3	33.8	56.4	53.8
SI	3.6	2.9	3.1	3.9	3.9	4.8	3.5	3.0	4.1	3.5	3.1	2.5
SK	10.0	11.2	19.2	40.6	54.3	37.1	6.1	6.8	11.7	24.6	33.0	22.6
UK	139.7	155.3	187.1	179.1	190.4	189.3	284.4	318.0	381.8	365.8	389.8	388.1
Total	1286.5	1462.3	1573.2	1616.9	1794.9	2004.7	1817.5	2112.5	2155.0	2017.4	2183.3	2328.9

Appendix 2. Harmonised estimates of emigration by country (in thousands) and area of destination, 2002-2007

	EU / EFTA						Rest of World					
Country	2002	2003	2004	2005	2006	2007	2002	2003	2004	2005	2006	2007
AT	26.0	28.5	31.3	33.9	39.3	42.2	21.9	29.0	31.3	34.2	39.0	38.9
BE	30.3	31.7	33.1	34.4	36.5	40.5	17.3	18.3	19.5	21.2	25.1	24.9
BG	31.3	40.1	39.9	37.4	40.0	62.1	20.6	20.9	21.8	23.6	27.0	26.8
CH	60.1	59.3	59.5	60.5	65.2	68.8	18.4	17.5	20.2	21.6	23.0	21.4
CY	9.1	6.8	9.0	12.1	9.6	13.6	24.2	14.4	20.3	32.4	22.2	36.8
CZ	29.6	30.5	34.8	36.5	43.3	34.2	157.8	166.8	169.7	117.3	163.1	99.9
DE	216.1	225.7	261.9	259.7	279.2	332.3	187.6	180.8	189.0	172.6	168.1	165.7
DK	17.3	17.5	18.4	18.7	20.4	20.9	11.2	11.4	12.2	12.7	12.8	10.8
EE	4.9	4.9	6.1	6.3	7.1	7.9	4.3	4.1	4.0	4.0	4.4	4.1
ES	54.5	67.5	66.5	71.5	106.2	148.7	53.9	94.6	81.1	100.1	209.4	334.1
FI	11.2	10.7	11.2	10.8	10.8	11.5	3.2	2.9	3.9	3.2	3.3	3.1
FR	79.1	82.3	89.2	94.9	101.6	112.1	78.2	84.3	90.3	98.2	115.7	116.8
GR	25.9	24.2	24.7	24.5	23.1	25.2	13.5	13.2	13.3	14.1	15.2	15.2
HU	27.0	26.4	31.5	35.3	37.3	42.6	26.4	26.9	28.4	30.4	34.2	33.7
IE	14.6	15.4	18.0	19.1	21.8	25.7	11.7	12.3	13.4	14.7	17.3	17.5
IS	3.4	3.1	3.2	3.2	3.4	3.6	0.4	0.6	0.7	0.8	0.8	1.1
IT	75.0	80.2	78.5	78.2	78.1	85.0	44.8	48.7	43.4	48.2	46.3	46.3
LI	0.2	0.2	0.3	0.3	0.2	0.3	0.1	0.1	0.1	0.1	0.1	0.1
LT	9.9	11.2	16.7	19.9	18.9	20.3	10.2	13.7	12.5	10.2	9.2	9.4
LU	9.1	9.8	10.2	10.7	10.4	11.6	0.9	1.0	0.8	1.2	0.7	0.9
LV	6.1	5.5	6.7	7.2	8.5	7.9	12.3	8.5	9.5	7.4	17.1	12.9
MT	1.3	1.4	1.4	1.4	1.7	1.7	2.3	2.4	2.5	2.6	2.9	2.8
NL	44.0	44.5	47.4	51.2	55.3	57.8	27.6	29.9	33.3	37.8	40.9	40.9
NO	16.7	16.5	15.9	15.1	15.8	16.3	6.0	6.0	5.7	5.5	5.7	5.3
PL	162.9	179.1	223.1	247.4	288.7	280.6	66.9	56.7	51.4	60.6	127.9	96.7
PT	27.5	29.5	30.2	30.8	33.4	37.6	14.4	15.0	16.1	16.7	19.2	19.1
RO	111.9	214.9	203.7	181.8	205.2	242.4	75.4	74.2	75.5	78.5	87.5	84.3

SE	23.1	24.3	25.7	27.0	28.5	30.8	9.8	10.5	11.3	11.9	14.8	13.7
SI	4.0	3.6	4.2	3.7	3.8	4.5	1.9	1.8	1.8	1.7	2.0	2.3
SK	42.7	48.5	50.6	57.9	61.8	72.8	10.5	8.9	11.8	20.8	23.0	13.7
UK	111.7	118.7	120.2	125.5	139.7	143.4	159.7	163.9	162.0	171.4	192.9	165.8
Total	1286.5	1462.3	1573.2	1616.9	1794.9	2004.7	1093.5	1139.1	1156.9	1175.9	1470.8	1465.2